

Food Chains and Food Webs

Every living thing in a habitat has to get its energy from somewhere, and almost all of it can be traced back to the same place. This chapter is about following that energy from one organism to the next.

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9.1 Producers and consumers

Green plants do something no animal can do: they make their own food. Using the energy in sunlight, they build sugars from carbon dioxide and water, and everything else they need to grow follows from that. Because they produce the food that enters the habitat, plants and algae are called **producers**.

No animal can do this. An animal has to take in food that is already made, which means eating a producer or eating something else that ate one. Animals are therefore called **consumers**. A consumer that eats producers directly is a **primary consumer**; one that eats primary consumers is a **secondary consumer**; and so on up.

Writing that sequence down gives a **food chain**. Figure 9.1 shows one from a grassland: grass is eaten by a grasshopper, the grasshopper is eaten by a shrew, and the shrew is eaten by an owl.

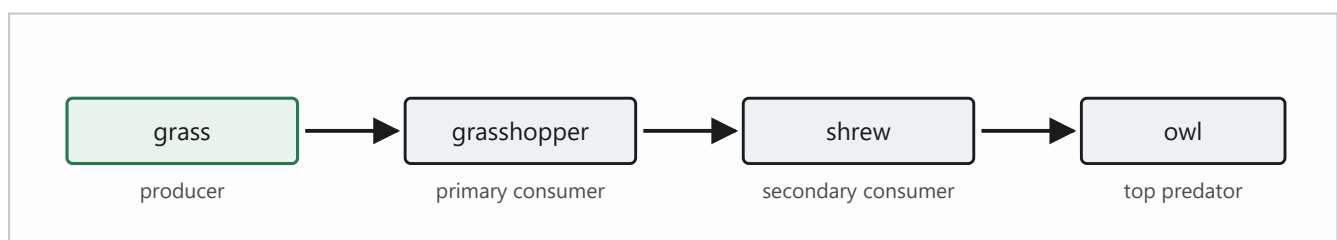


Figure 9.1 A food chain from a grassland habitat.

The arrows are the part people get wrong, so read them carefully. An arrow **points from the food to the feeder** — from the organism that is eaten towards the organism that eats it. It is showing the direction the energy travels, not who is hunting whom. Draw the arrow the other way round and you have said that the grass eats the grasshopper.

9.2 Reading a food web

A single chain is tidy, but it is not honest about a real habitat. Very few animals eat only one thing, and very few are eaten by only one thing. A shrew that cannot find grasshoppers will eat beetles instead, and the owl will happily take a mouse or a vole. So the chains in a habitat are not separate: they share organisms, and they cross.

Drawing all of them together gives a **food web**. It uses exactly the same arrows, with the same meaning as before, but an organism can now have several arrows leaving it and several arriving at it. An arrow arriving means "this is eaten by"; several arrows arriving mean the organism has more than one predator. Several arrows leaving mean it has more than one source of food.

Figure 9.2 is the food web of Fenmoor Ditch, a slow stretch of water on the edge of a farm. You will need to be able to read it. Take a moment now to trace two or three paths through it from a producer up to a top predator, following the arrows, and notice where a path meets a junction and could go two ways.

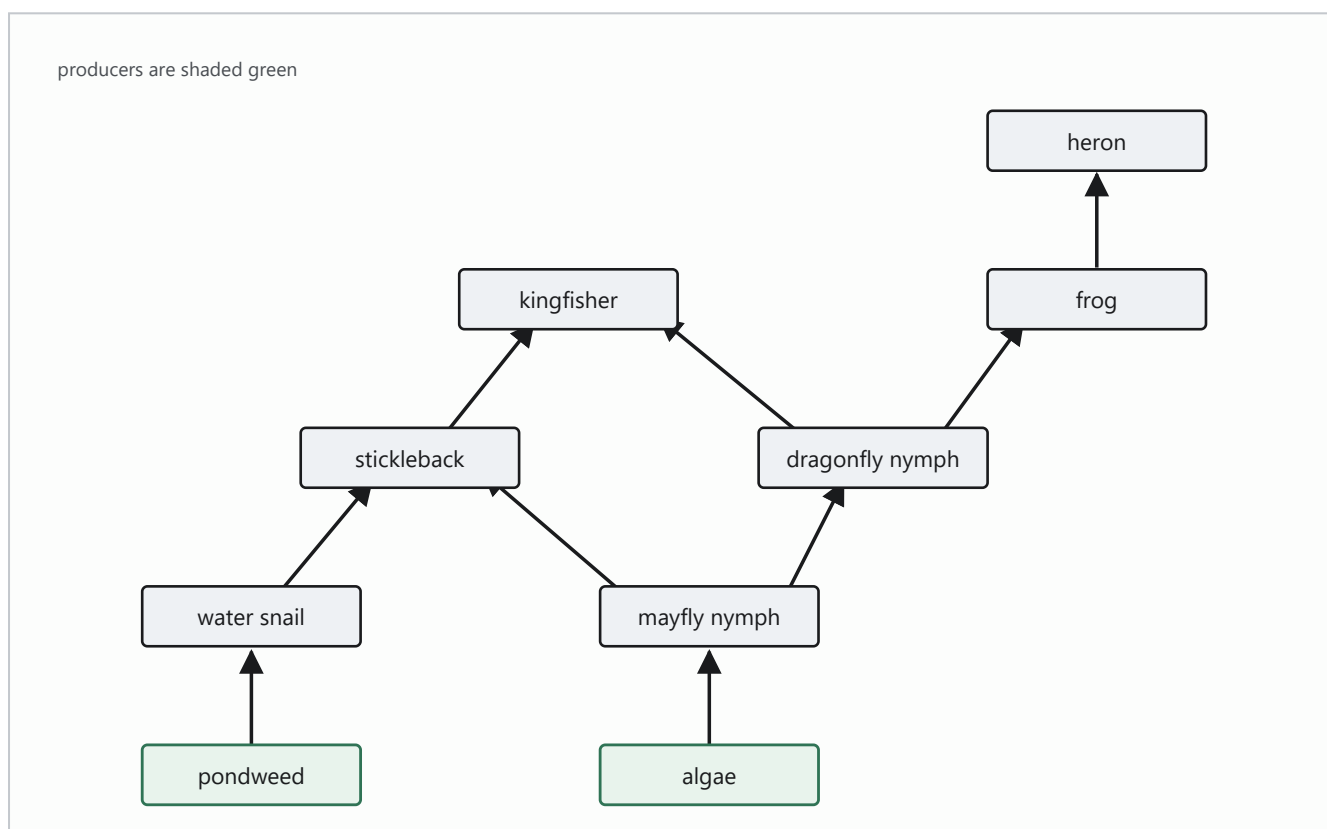


Figure 9.2 The food web of Fenmoor Ditch.

Nothing about where the boxes sit on the page carries any meaning. The same web can be drawn tall or wide, with the producers along the bottom or down one side, and it remains the same web so long as every arrow still joins the same pair of organisms in the same direction. Two biologists surveying the same ditch would almost certainly produce drawings that looked different and said the same thing.

WHAT A WEB WILL AND WILL NOT TELL YOU

A web records **who eats whom**, and that is all. It does not say how many of each organism there are, how often a meal is taken, or which food an animal prefers when it has a choice. An arrow drawn between two organisms means the one is eaten by the other at least sometimes — no more than that. Keep that in mind before drawing a confident conclusion from a diagram like Figure 9.2.

9.3 Energy along a chain

Follow a chain upwards and the numbers fall away sharply. A meadow holds an enormous quantity of grass, a large number of grasshoppers, rather few shrews and perhaps a single pair of owls. That pattern is not a coincidence, and it is not because owls are hard to find. It is a direct consequence of what happens to energy at every step.

When a grasshopper eats grass, only a small part of the energy in that grass ends up stored in the grasshopper's own body, where the next animal along could get at it. Some of the plant is never eaten at all — the roots, the tough stems. Some passes straight through undigested. Most of what is actually absorbed gets spent on staying alive: moving, breathing, keeping warm, repairing damage. Energy spent that way leaves the animal as heat, and heat cannot be eaten. It is gone from the chain for good.

As a rough guide, about a tenth of the energy at one level is passed on to the next. Table 9.1 works that through for the grassland chain in Figure 9.1, starting from the energy the grass captured in a year.

Table 9.1 Energy passed on at each level of the grassland chain, per square metre per year.

Level	Organism	Energy available
producer	grass	21 000 kJ
primary consumer	grasshopper	2 100 kJ
secondary consumer	shrew	195 kJ
top predator	owl	18 kJ

Two things follow from that column of numbers, and both are worth stating plainly.

The first is that **food chains are short**. By the fourth level there is so little energy left that a fifth is rarely worth supporting; a predator that fed only on owls would starve. Habitats therefore have four or five levels at most, not twenty.

The second is that **top predators are always rare**. An owl needs the energy of a great many shrews, each of which needed a great many grasshoppers, each of which needed a great deal of grass. The animal at the top of a chain is supported by everything below it, so there can never be many of them — which is also why top predators are usually the first animals to disappear when a habitat is disturbed.

9.4 Decomposers

Something is missing from every diagram so far. Plants and animals die, and animals produce waste, and none of that simply accumulates. If it did, a wood would be buried under centuries of its own dead leaves.

The organisms that deal with it are the **decomposers**: mainly bacteria and fungi, helped by small animals such as earthworms and woodlice. They feed on dead material and waste, breaking it down and taking their own energy from it. In doing so they release the nutrients locked up in that material — nitrogen, phosphorus and the rest — back into the soil and water as simple substances that plant roots can absorb again.

That last part is why decomposers matter so much. Energy makes a one-way journey through a habitat: it arrives as sunlight and leaves as heat, and nothing sends it back. **Nutrients do not behave like that.** They go round and round — soil to plant, plant to animal, animal to decomposer, decomposer back to soil — and the decomposers are the step that closes the loop. Without them the nutrients would stay locked inside dead bodies, the soil would run out, and the producers would fail. Every chain and every web in this chapter depends on organisms that are not usually drawn in it.

It is worth being clear about what decomposers are, because they are easy to file in the wrong place. They are not producers: they cannot make food from sunlight, and they need material that was alive to feed on. They are consumers, like any animal — the difference is only that what they consume is already dead. A fungus growing on a fallen branch is doing the same thing in principle as a shrew eating a grasshopper.

They are usually left out of diagrams for a practical reason rather than a scientific one. Almost everything in a habitat eventually dies and is decomposed, so an honest drawing would need an arrow from every single box to the decomposers, and the diagram would become unreadable. Leaving them out keeps the picture clear, but it does mean that every food chain and every food web you meet is incomplete in the same way. Remember that they are there.

ACTIVITY 9.1 — REDRAW A WEB

Copy the food web of Figure 9.2 onto a fresh sheet of paper, but arrange the boxes differently: put the producers down the left-hand side instead of along the bottom, and place every other organism wherever it needs to go. Keep every arrow, and keep each arrow pointing the same way round as it does in the figure.

Then add decomposers to your drawing. Decide for yourself where they belong and what arrows should run to and from them, and be ready to explain your choice. Finally, compare your drawing with a neighbour's. The boxes will be in different places, but if you have both worked carefully the arrows should connect the same organisms — because the layout of a web is your choice, and the connections are not.

9.5 Changing one link

Because the organisms in a web are connected, a change to one of them is never confined to that one. Suppose a disease removes a primary consumer from a habitat, or a pond is treated and loses one of its plants. What happens next depends entirely on the shape of the web, which is why being able to read one matters.

Start with what is eaten. Anything that fed on the missing organism has lost a food source. If it had others, it will lean on those instead and its numbers may barely change — but the organisms it switches to will now be eaten more heavily than before, so the effect travels sideways into parts of the web that seem unrelated. If the missing organism was its *only* food, that predator is in serious trouble, and so is anything that depended on the predator in turn.

Then look the other way. Whatever the missing organism used to eat is now eaten less, so it becomes more common. A pond that loses the animals grazing its algae can turn green within weeks.

READING IT OFF THE DIAGRAM

Both questions can be answered from a web without knowing anything else about the animals. Count the arrows arriving at an organism to see how many predators it has, and count the arrows leaving it to see how many foods it has. An organism with one arrow leaving is vulnerable; one with three is not. This is the practical reason a biologist draws the web before predicting anything.

WORKED EXAMPLE

Question. In the grassland chain of Figure 9.1, a disease kills most of the grasshoppers one summer. Give one effect on the grass and one on the owls, and say which of the two you are more confident about.

Answer. The grass is grazed less, so it grows thicker. The shrews lose their food source, so fewer shrews survive, so the owls have less to eat and their numbers fall too. The effect on the grass is the more confident of the two: it is one step away and immediate. The effect on the owls is two steps away and depends on whether shrews and owls have other foods available — and Figure 9.1 is a chain, which shows no other foods even if they exist. This is exactly why a web is more useful than a chain for predicting anything.

None of this is a formula, and a real habitat will always hold surprises. But the general rule is reliable enough to be worth remembering: the more connections an organism has, the less a change to any single one of them matters, and a web with many connections recovers from disturbance far better than a web with few.

The word "ditch" undersells Fenmoor. Slow, shallow water at the edge of farmland is among the richest habitat there is, precisely because it holds so many producers within reach of the light.

Fenmoor Ditch was surveyed over three summers. The animals recorded there are ordinary for this kind of water; what varies from one such site to the next is which of them happen to be present together.